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BRIEFER ARTICLES.

CLUES TO RELATIONSHIP AMONG HETEROECIOUS PLANT RUSTS.[1]

THE collection and study of Uredineae are beset with a difficulty not found in connection with other classes of plants. A large number of species, principally belonging to the genera Puccinia and Uromyces, inhabit two wholly diverse species of host, and the form of the fungus assumed upon one host gives no clue to the alternate form upon the other kind of host. If teleutospores, for instance, are found upon a grass, there can be nothing detected in the morphology of the rust or of its host, with possible rare exceptions, to indicate whether the corresponding aecidiospores are to be looked for upon a monocot or a dicot, upon a liliaceous, ranunculaceous, or composite plant, or plant of some other family, upon a tree, shrub, or herb; in fact there is no clue whatever. So it comes about that the two halves of heteroecious species are usually gathered separately and listed independently under different genera.

Probably most localities will furnish from a dozen to twenty-five species of aecidia, and *per contra* the same number of unattached teleutosporic forms. Or, to use the prevailing method of expression, there will be so many heteroecious species showing teleutospores, and an equal number of undistributed aecidia. Yet it stands to reason that whether the aecidial or the teleutosporic half be found, still it is but half the species. Contrary to general opinion, there is no definite proof that the one half has any more physiological or taxonomic importance than the other, and the small consideration at present given by collectors and students to the aecidial forms is unfortunate and unwarranted.

For some time I have carried on successful cultures with the heterœcious Uredineae, by which spores of one half of a species were sown, and eventually gave rise to the spores of the other half of the same species. To accomplish this it is necessary to have a pretty clear clue to

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the host on which the second half grows. For instance, if I have teleutospores, found upon a grass in germinating condition, shall I sow them upon a geranium, gooseberry, buckeye, thistle, or some other one of a hundred or more plants known to bear aecidia? I might try each one in succession, and hope eventually to hit upon the right one. But the chances of success by this method are few, in fact, according to my experience, far too few to warrant its use. On the contrary, in order to cherish any reasonable hopes of success it is necessary to possess very definite clues. The method of obtaining these clues I desire especially to call attention to, for it seems to me that observation of this kind will add at times much interest to collecting, and provide valuable data to supplement that usually taken.

To make the problem more concrete, I may state that during the present season I have grown from teleutosporic material the common aecidia on Sambucus, Erigeron, and Aster, and an aecidium on Ribes that appears to be different from the common form. The teleutospores for these four species of rusts came from as many different species of Carex, and have heretofore been erroneously listed as *Puccinia Caricis*. The taxonomic significance of these results will be brought out when the data are ready for publication; it is now only intended to be shown how I came to sow these particular teleutospores upon the right hosts.

In the first place, all observations affording clues (with such exceptions as the similarity in form between uredospores and aecidiospores to be detected only with the microscope, which are so rare as to be negligible) must be made in the field. For the most part they must be made previous to the season when the cultures are undertaken. It is advantageous, indeed, to watch the same rusted plants, or clumps and areas of rusted plants, from season to season. In this way the interest is not so much centered in the specimens carried away, as in the fungus crop that is left behind. When specimens are gathered, they are labeled not only with the usual data, but with sufficiently exact directions so that the spot may be found again. The same host plants are then examined from time to time as the succession of spore-forms appears — spermogonia, aecidia, uredo, amphispores, and teleutospores, all or in part as the case may be. It is like watching for a succession of blooms, and the pleasure of collecting is much enhanced. The whole available territory over which one may ramble or drive now becomes mapped out into specific localities where this, that, or the

other kind of rust grows, and what was mere collecting has resolved itself into an ecological study of absorbing interest.

Only a rich and plentiful occurrence of the rust, whether over wide or restricted areas, is of much value to furnish a clue to relationship. Scattering aecidia or teleutospores generally mean that the source of infection is at a considerable distance, and what is found has come from chance spores blown long distances by the wind. Species vary much as to the distance spores may be carried in condition to start infection, but for our present purpose any distance from a hundred feet to a mile or more is likely to be enough to render our deductions very uncertain.

Probably the easiest and clearest clue is obtained by watching for the first appearance of aecidia. If they can be found thickly covering the leaves of a vigorous plant, especially near the ground, and very few or no aecidia of the same kind upon adjoining plants of the same species, let us search carefully underneath for dead leaves of grass or sedge bearing teleutospores, and for a foot or two around. If these can be found, a little additional search will generally bring to light fragments of last year's inflorescence, by which the specific identity of the teleutosporic host may be determined. The leaves closest to the rusted grass or sedge, which is presumably the source of infection, should bear the thickest sprinkling of aecidial spots. If now a careful search reveals within a radius of ten or twenty feet, only this one grass or sedge bearing teleutospores, we have good reason to assume that the aecidia have arisen from sporidia derived from the recent germination of the teleutospores, and that the two are parts of the same species. By continuing our observations we ought to find after a time, if the weather is propitious, that uredosori are appearing upon the green grass (or sedge) leaves, more abundantly upon those close to the aecidia, and fewer the greater the distance. Only the earliest sori can be of value for our purpose, because uredospores germinate readily, as a rule, and give rise to uredosori that cannot be distinguished from those arising from aecidiospores. If such juxtaposition of the two kinds of spore formation, such coinciding of two centers of infection, be found elsewhere, or for more than one season, especially when other sorts do not occur in a way to cause confusion, we are provided with a strong clue to relationship. Of course, nothing short of cultures will enable one to be perfectly certain. A clue of this sort led to the right sowing for the Aster aecidium mentioned above.

Such good fortune as finding the two halves of a rust so clearly

associated does not occur frequently, although more often than the uninitiated might suppose. A clue of less value may be obtained by finding a limited area monopolized by a single species of grass or sedge, the whole well rusted. We now search for aecidia upon herbs, shrubs, or trees growing within the rusted area, or not to exceed a hundred feet from it. Abundance and nearness, and taking into account all other forms, give us our clue. This was the kind of clue used for the sowing of Sambucus. A Carex of very distinctive habit, species unknown as the plants were sterile, grew in a thick mass, not over ten feet across, that was heavily rusted each season. This spot had been under observation a number of years. No other locality in the immediate region was known for the Carex, and owing to the character of the surrounding ground, it could scarcely find a foothold within a half mile, or possibly much more. No aecidia appeared on any plant growing among the Carex, or within ten feet of it. It was a rich region for plant rusts, and within one hundred feet aecidia were found upon Ranunculus, Oenothera, Impatiens, Eupatorium, Napaea, Sambucus, Ptelea, and Urtica. The aecidia of Ptelea and Urtica were known to belong to other teleutospores ; the aecidia on Ranunculus and Oenothera were too abundant and widely diffused through the adjoining region to warrant their being considered. This left four kinds of aecidia sufficiently local to be accepted for trial, and after two season's work it has been positively ascertained that this particular Carex rust must belong to the aecidium on Sambucus.

When a rust occurs very sparingly in a region, but richly developed, or when it is restricted to a rare host, close watch in the immediate vicinity is sometimes rewarded by the discovery of the alternate form. Occasionally this alternate form is so conspicuous that it has been previously collected, but not infrequently it proves to be a sort not before recorded for the district.

The better one becomes acquainted with the rusts of a small region, the more chances there are that his inferences regarding relationship will stand the test of cultures. If he does not make cultures himself, some one may be found who will be willing to undertake the sowings, provided material be furnished. This consists of small living plants of the supposed host of the aecidia, and grass or sedge leaves bearing the rust, the latter gathered during the previous winter and subsequently kept out of doors. Both are readily sent by mail at a trifling cost. Cultures with use of aecidiospores are also important, but less

easily arranged for when they are to be made at a distance from the source of material. Sometimes a single sowing of teleutospores determines the point in question, but for a variety of reasons it usually does not. A common source of difficulty is the failure of the teleutospores to germinate. But these are details pertaining to a separate matter. It will be many years before any large proportion of our numerous heteroecious rusts will be connected with their respective aecidia, and in the meantime all clues to relationship will be much prized by students, and their pursuit will give to the collector an additional source of pleasure.—J. C. ARTHUR, *Purdue University*.